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# Kernel Quality Association and Path Analysis in Bread Wheat

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**Abstract**

The correlation and path coefficient analysis of some kernel quality traits have been studied for 92 cultivars, breeding lines and landrace varieties of bread wheat (*Triticum aestivum* L.). Ninety-two genotypes were evaluated in alpha lattice design with two replications. Result of analysis of variance indicated that there were significant differences among genotypes in the most of traits. The correlation analysis showed that there were significant positive correlations among thousand kernel weight (TKW), grain length (GL) and grain width (GW). We also showed TKW, GL and GW had positive correlation with grain protein percentage, gluten weight, and falling number. Grain protein was significantly correlated with several kernel characteristics including: TKW, GL, GW, hardness index, gluten weight, SDS sedimentation, and falling number. On the first and second steps of stepwise regression analysis, protein percentage and falling number were the most effective traits in explaining different trait variations. Path coefficient analysis also showed the direct and significant effects of grain protein percentage and medium direct effect of falling number on SDS sedimentation. This result can be used in wheat breeding programs.

**Keywords:** bread wheat, quality traits, correlation analysis

## 1. Introduction

The trait correlations are important in plant breeding, because of its reflection in dependence degree between two or more traits. Correlations between traits are depending of genetic and environmental factors (Falconer, 1981). Correlations themselves express only the degree of traits interrelationships, while path analysis provides analytically better survey of yield expression, as a resultant of its components. But it is not point to nature of that dependence. It is necessary to calculate path analysis of correlation coefficients, because this method enable quality and complete recognize ratio between investigation components. Since path-coefficient analysis was applied by Dewey and Lu (1959) on crested wheat grass, this technique has been followed extensively to facilitate selection in various crops. Existing correlation between components, expressed through correlation coefficients separate on direct and indirect influence by path method (Li, 1975; Penchev & Stoeva, 1989; Garcia Del Moral et al., 1991). Path coefficient analysis divides correlation coefficients into a measure of direct and indirect effects within a system of correlated traits. If there have been genetic relations among traits, selection for one trait would result in modification of another one, i.e. correlation response to selection would be obtained (Trifunovic, 1995). Correlation coefficient is helpful in determining main traits influencing grain protein content and grain yield for indirect selection criteria. However, it provides incomplete information regarding relative importance of direct and indirect effects on individual factors involved (Zecevic et al., 2004). Positive and significant correlations were observed among thousand kernel weight (TKW), kernel length (KL) and kernel width (KW), which suggested that selection for heavier kernels might lead to indirect selection for larger seeds (Ramya et al., 2010). In earlier studies, Dholakia et al. (2003) and Breseghello and Sorrels (2007) reported positive correlations among kernel weight, Huang et al. (2006) indicated that grain protein content (GPC) was highly correlated with flour protein content (FPC). Both GPC and FPC showed a positive correlation with SDS sedimentation volume (SV) and most mixograph parameters except mixing development time (MDT) and energy to peak (ETP). They also reported the strongest correlation ($r = 0.943$) between MDT and ETP. Negative correlations were found between grain yield and GPC ($r = -0.043$), but were not significant. Radovanovic et al.

(2002) reported that grain protein concentration was not significantly affected by HMW glutenin composition. Tayyar (2010) showed that grain yield was negatively correlated with gluten and positively correlated with hectoliter weight whereas there was no correlation with protein, gluten index and grain moisture. Jochen et al. (2011) reported that low and high phenotypic correlations between 1000-kernel weight and test weight (r = 0.04) and between protein content and sedimentation volume (r = 0.60) were exist. The higher SDS sedimentation volume causes more gluten strength. SDS sedimentation volume, were correlated with qualitative traits, including volume of bread, gluten strength and protein content. Therefore, SDS sedimentation volume is an appropriate tool for predicting the breadmaking properties in bread wheat (Campbell et al., 1987; Grama et al., 1987; Gupta et al., 1995). Shahin Nia et al. (2002) reported that positive significant correlation between protein percentage, SDS sedimentation test and other bread-making quality traits were exist. On the first and second steps of stepwise regression analysis, protein percentage was the most effective trait in explaining different qualitative trait variations. Path analysis also showed the direct and significant effects of protein percentage, Zeleny sedimentation volume, grain moisture content and flour water absorption percentage, and bread volume on SDS sedimentation.

The present study was initiated to investigate the interrelationship of some wheat traits and the type and extent of their contribution to seed quality of bread wheat. The information's so derived could be exploited in devising further breeding strategies and selection procedures to develop new varieties of wheat capable of high productivity.

## 2. Materials and Methods

### *2.1 Plant Materials and Experimental Design*

This study was carried out in Research Field of Seed and Plant Improvement Institute, Karaj, Iran, during 2011-2012 cropping season. The materials consisted of Ninety-two bread wheat genotypes (including 82 cultivar and 10 promising breeding lines, Table 1), that either have been cultivated previously or are under cultivation at present in different regions of Iran and used widely in wheat production as well. An alpha lattice design with two replications were used, each plot contained 4 rows, 20 cm apart and 4 m in length.

### *2.2 Measurement of Kernel Quality Traits*

Grain protein percentage and grain hardness were estimated by Near-Infrared-Reflectance (respectively method AACC 39-10 and method AACC 39-70A). The gluten content was determined by method AACC 38-12. The SDS sedimentation volume was determined by measuring the SDS sedimentation volume according to method AACC No, 56-70. The falling number was determined by method AACC No, 56-81. GW, GL and TKW of wheat genotypes were measured using a balance with an accuracy of 0.01gr. Analysis of variance, correlation among traits, stepwise multivariate regression and path analysis were performed using *alpha, SPSS* and *Path2 software,* respectively.

## 3. Results and Discussion

### *3.1 Analysis of Variance and Correlation Analysis*

Analysis of variance showed significant differences for all traits, except for falling number (Table 2). The significant difference among genotypes for traits implies the presence of variation among genotypes. Correlations among all traits measured are summarized in Table 3. Thousand kernel weight (TKW) had significant positive correlation with grain length (GL) and grain width (GW) respectively ($r = 0.68^{**}$ and $r = 0.39^{**}$).

Table 1. Names of bread wheat genotypes used in the study

| No | Name/Identity | Growth type | No | Name/Identity | Growth type |
|---|---|---|---|---|---|
| 1 | Karaj-1 | Facultative | 47 | Morvarid | Spring |
| 2 | Karaj-2 | Facultative | 48 | Gonbad | Spring |
| 3 | Karaj-3 | Winter | 49 | Arvand | Spring |
| 4 | Azadi | Spring | 50 | Chenab | Spring |
| 5 | Ghods | Spring | 51 | Bayat | Spring |
| 6 | Mahdavi | Facultative | 52 | Falat | Spring |
| 7 | Niknejad | Spring | 53 | Heirmand | Spring |
| 8 | Marvdasht | Spring | 54 | Darab-2 | Spring |
| 9 | Pishtaz | Spring | 55 | Atrak | Spring |
| 10 | Shiraz | Spring | 56 | Chamran | Spring |
| 11 | Sepahan | Spring | 57 | Star | Spring |
| 12 | Bahar | Spring | 58 | Dez | Spring |
| 13 | Parsi | Spring | 59 | Vee/Nac | Spring |
| 14 | Sivand | Spring | 60 | Line A | Spring |
| 15 | M-85-7 | Spring | 61 | Aflak | Spring |
| 16 | WS-82-9 | Spring | 62 | Baaz | Spring |
| 17 | Sirvan | Spring | 63 | Shahpasand | Winter |
| 18 | DN-11 | Spring | 64 | Omid | Winter |
| 19 | Bezostaya | Winter | 65 | Roshan | Facultative/Spring |
| 20 | Navid | Facultative/Winter | 66 | Tabassi | Facultative |
| 21 | Alamout | Facultative/Winter | 67 | Sholleh | Spring |
| 22 | Alvand | Facultative | 68 | Sorkhtokhm | Spring |
| 23 | Zarin | Facultative | 69 | Adl | Facultative |
| 24 | MV-17 | Winter | 70 | Sardari | Winter |
| 25 | Gaspard | Winter | 71 | Azar-2 | Winter |
| 26 | Gascogne | Winter | 72 | Zagross | Spring |
| 27 | Soisson | Winter | 73 | Sabalan | Winter |
| 28 | Shahriar | Winter | 74 | Sp.Bc of Roshan | Spring |
| 29 | Tous | Winter | 75 | Wi. Bc of Roshan | Winter |
| 30 | Pishgam | Facultative | 76 | Cross of Shahi | Winter |
| 31 | Mihan | Winter | 77 | Maroon | Spring |
| 32 | Oroom | Facultative | 78 | Kavir | Spring |
| 33 | Zaree | Winter | 79 | Hamoon | Spring |
| 34 | Inia | Spring | 80 | Bam | Spring |
| 35 | Khazar-1 | Spring | 81 | Akbari | Spring |
| 36 | Mughan-1 | Spring | 82 | Sistan | Spring |
| 37 | Mughan-2 | Spring | 83 | Arg | Spring |
| 38 | Mughan-3 | Spring | 84 | UN-11 | Winter |
| 39 | Golestan | Spring | 85 | Kohdasht | Spring |
| 40 | Alborz | Spring | 86 | Ohadi | Winter |
| 41 | Kaveh | Facultative | 87 | Rijav | Facultative |
| 42 | Rassoul | Spring | 88 | Rasad | Winter |
| 43 | Tajan | Spring | 89 | Karim | Spring |
| 44 | Shiroudi | Spring | 90 | Ch | Winter |
| 45 | Darya | Spring | 91 | Homa | Winter |
| 46 | Arta | Spring | 92 | Norstar | Winter |

Table 2. Analysis of variance of traits

| | | MS | | | |
|---|---|---|---|---|---|
| S. O. V | df | Protein percentage | Hardness index | Gluten weight | SDS Sedimentation |
| Replication | 1 | 4.11 | 33.62 | 744.98 | 5.44 |
| Block (adjustment) | 18 | 0.046 | 8.37 | 18.49 | 2.97 |
| Treatment | 99 | 0.41 | 16.20 | 15.18 | 39.09 |
| Treatment (adjustment ) | 99 | 0.78 ** | 13.69 ** | 7.71 * | 35.68 ** |
| Residual | 81 | 0.047 | 5.56 | 4.74 | 3.01 |
| Total | 199 | | | | |

Table 2. Continued

| | Grain length | Grain width | Thousand kernel weight | Falling number |
|---|---|---|---|---|
| | 5.74 | 1.36 | 9.30 | 275356.10 |
| | 0.04 | 0.09 | 4.66 | 8281.92 |
| | 0.53 | 0.19 | 34.95 | 9898.16 |
| | 0.44 ** | 0.19 ** | 26.23 ** | 8407.60$^{ns}$ |
| | 0.07 | 0.08 | 3.12 | 6236.85 |

Table 3. Simple correlation coefficients matrix belonging to traits

| Trait | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| 1-Protein percentage | 1 | | | | | | | |
| 2-Hardness index | 0.36** | 1 | | | | | | |
| 3-Gluten weight | 0.53** | 0.14 | 1 | | | | | |
| 4-SDS sedimentation | 0.22** | -0.08 | 0.10 | 1 | | | | |
| 5-Grain length | 0.18 | 0.07 | 0.21* | 0.08 | 1 | | | |
| 6-Grain width | 0.21** | 0.05 | 0.19 | 0.08 | 0.26** | 1 | | |
| 7-Thousand kernel weight | 0.33** | 0.18 | 0.23* | -0.04 | 0.68** | 0.39** | 1 | |
| 8- Falling number | 0.25** | 0.12 | 0.34** | 0.15 | -0.04 | 0.17 | 0.17 | 1 |

These suggesting that heavier and larger kernels had a higher TKW. This result was in agreement with the works of Zecevic et al. (2004) and Ramya et al. (2010). Additionally our results were in agreement with Lee et al. (2006), who reported strong correlation (r = 0.83) between kernel weight and size. TKW, GL and GW had positive correlation with protein percentage, gluten weight, and falling number. Several researchers have also reported that kernel weight and size are important because of their relationships with milling quality, for example, an increase in flour yield resulted from an increase in kernel weight (Wiersema et al., 2001), or kernel size (Marshal et al., 1984; Berman et al., 1996).

However, the improvement of kernel weight and size alone has generally been found to have no benefits on grain yield. Protein percentage was significantly correlated with several kernel characteristics including: Hardness index, gluten weight, SDS sedimentation, TKW, GL, GW and falling number. These were agreement with results of Shahin Nia et al. (2002) that reported positive and significant relationship between protein percentage, SDS sedimentation test and other bread-making quality traits.

Gliadins and glutenins are major storage protein of wheat. These are the main component of gluten, which are primarily responsible for the viscoelasticity on dough and breadmaking properties (Branlard et al., 2001). In general high grain protein content has been associated with good breadmaking quality. The wheat grain protein content is affected by some factors such as variety, location, crop year, temperature, rainfall, soil fertility etc. These are most important points for the producers as well as flour technologists, millers and bakers (Tayyar, 2010). Previous study also pointed out that the protein content of wheat was mainly dependent upon genotype (Stoddard, 1990). There were no undesirable relationships among other traits.

### *3.2 Stepwise Regression and Path Analysis*

Using stepwise regression protein percentage and falling number were the most important component. These traits were the most effective trait in explaining different qualitative trait variations (Table 4), in the case of grain protein, these result also reported by Shahin Nia et al. (2002). Estimates of direct effect path coefficient and indirect effect path coefficient are presented in Table 5. Grain protein percentage had significant and positive, falling number had medium direct effect on SDS sedimentation. This indicated that with regard to constant other variables, an increase of these traits, seed quality traits has been improved. This result was in agreement with those reported by Shahin Nia et al. (2002). The results of this analysis indicates that, in breeding programs selecting the best genotypes for these traits lead to increase protein content and consequently improve the baking quality of wheat. Fowler et al. (1990) and Campbell et al. (1987) in previous studies have pointed to this subject.

Table 4. Stepwise regression for kernel traits

| Dependent variable | No | Variable Entered | R Square | | MS | *a* | Regression coefficient |
|---|---|---|---|---|---|---|---|
| | | | Relative | Cumulative | Regression | | |
| Dependent variable (DP) | 1 | Protein | 0.51 | 0.51 | 90.54 | 28.24 | $3.86^{**}$ |
| | 2 | Falling number | 0.49 | 0.100 | 177.40 | 25.71 | $-0.016^{*}$ |

DP = SDS. Sedimentation.

Table 5. Direct (parenthesis) and indirect effect of two traits

| | $X_1$ | $X_2$ | Total |
|---|---|---|---|
| $X_1$ | (0.102) | 0.048 | 0.15 |
| $X_2$ | 0.023 | ($0.217^{*}$) | 0.24 |

$X_1$= Falling number $X_2$= Protein percentage

Dependent variable: SDS, Sedimentation

In Table 2, 3, 4 and 5, * and **: significant at 5%, 1% probability levels, respectively.

In Table 2 and 4: MS = Mean Square.

## 4. Conclusion

The present study depicted substantial variation among bread wheat genotypes for seed quality traits, which gives an opportunity to plant breeders to improve these traits. It is evident according to the results of this study, to evolve bread wheat genotypes with ultimate higher seed quality traits, attention should be focused selecting plant traits which have positive direct effect on seed quality traits.

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